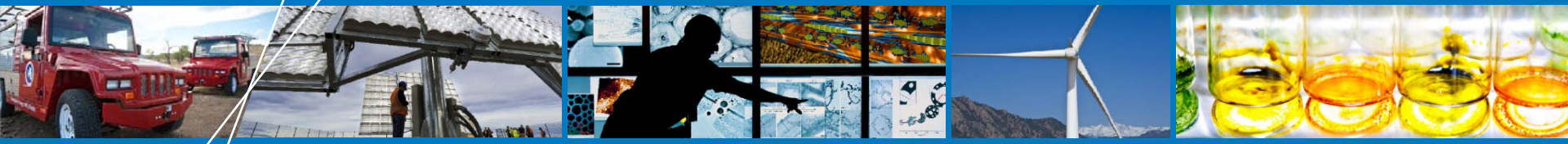
NREL
NATIONAL RENEWABLE ENERGY LABORATORY



Energy Systems Integration Facility Capabilities

Bill Kramer, PhD

Distributed Energy Systems Integration Group Manager

Construction Has Started!

April 2011

May 2011

June 2011

July 2011

August 2011

September 2011

Today

West Elevation and Main Entrance

ESIF – Major Laboratories

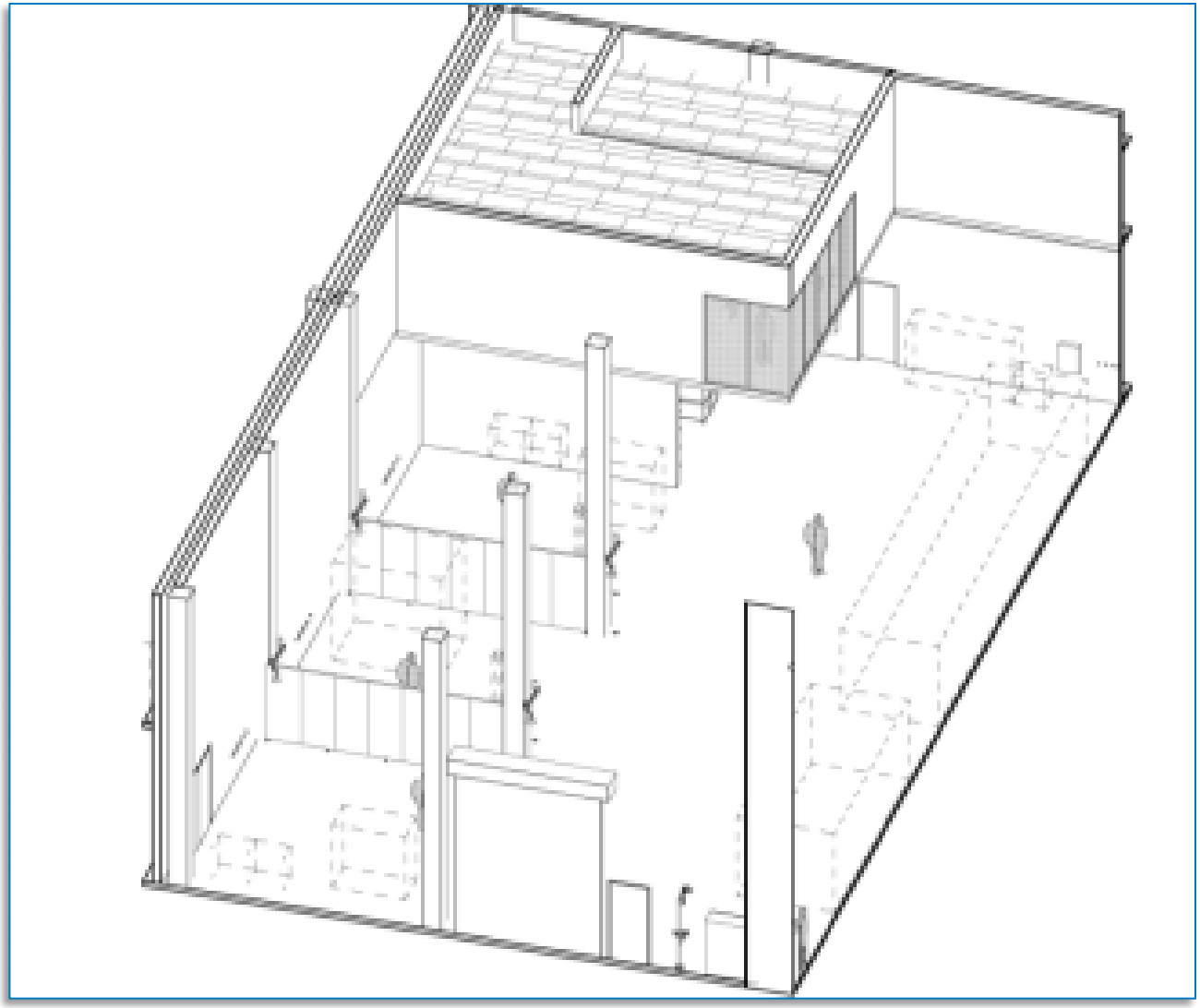
Electricity Laboratories

- Power Systems Integration Lab
- Smart Power Lab
- Energy Storage Lab
- Electrical Characterization Lab
- Energy Systems Integration Lab
- Outdoor Test Areas
- Optical Characterization Lab

Fuels, Chemical, and Thermal Labs

- Thermal Storage Materials Lab
- Thermal Storage Process and Components Lab
- Energy Systems Fabrication Lab
- Manufacturing Lab
- Materials Characterization Lab
- Electro-Chemical Characterization Lab
- Energy Systems Sensor Lab
- Fuel Cell Development and Test Lab

ESIF – Power Systems Integration Lab



ESIF – Power Systems Integration Lab

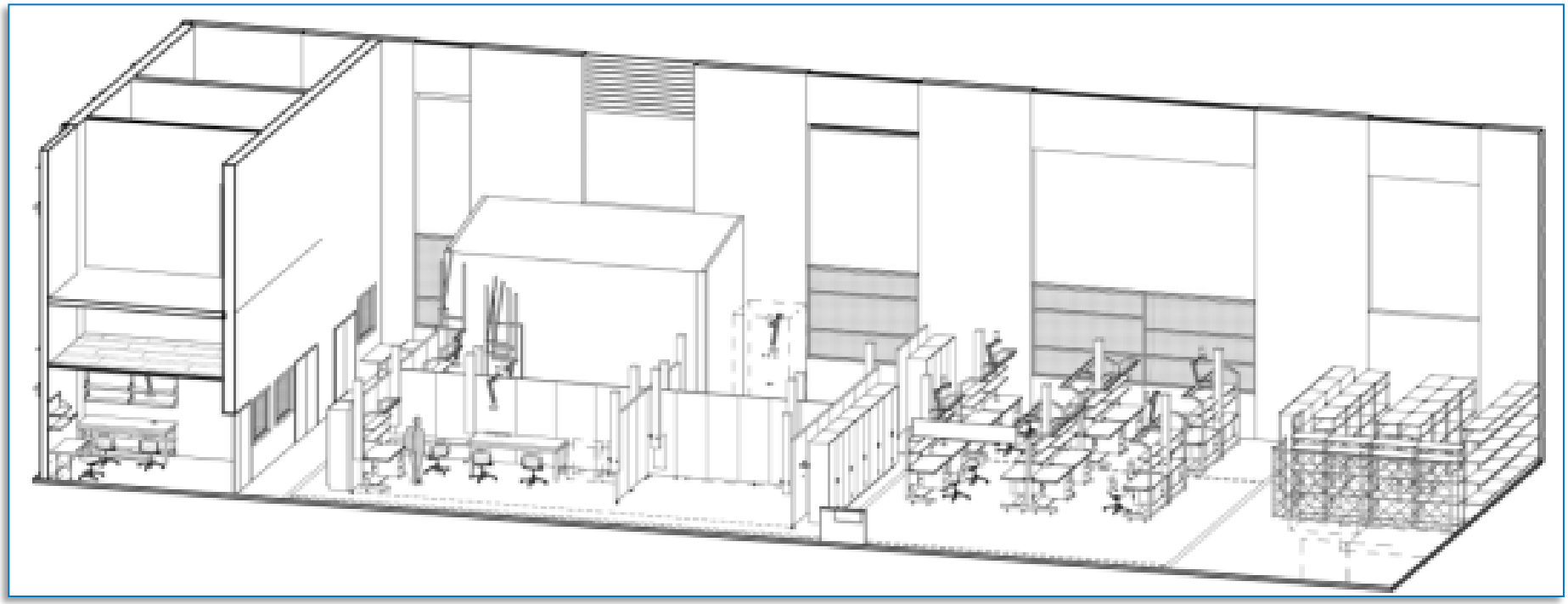
Lab Functions

- Main test lab for conducting electrical system integration activities.
- Research will include exploring a variety of operating configurations including: grid connected stand-alone, microgrids, and hybrid power systems.
- House infrastructure for DG research (AC and DC power supplies for REDB, chiller and boiler)

Major Laboratory Equipment

- Hardware-in-the-Loop Simulator
- Grid simulator
- AC load banks
- Bidirectional DC supplies
- Research Chiller
- Research Boiler
- SCADA Data Collection and Control System
- PV Simulator

ESIF – Smart Power Lab



ESIF – Smart Power Lab

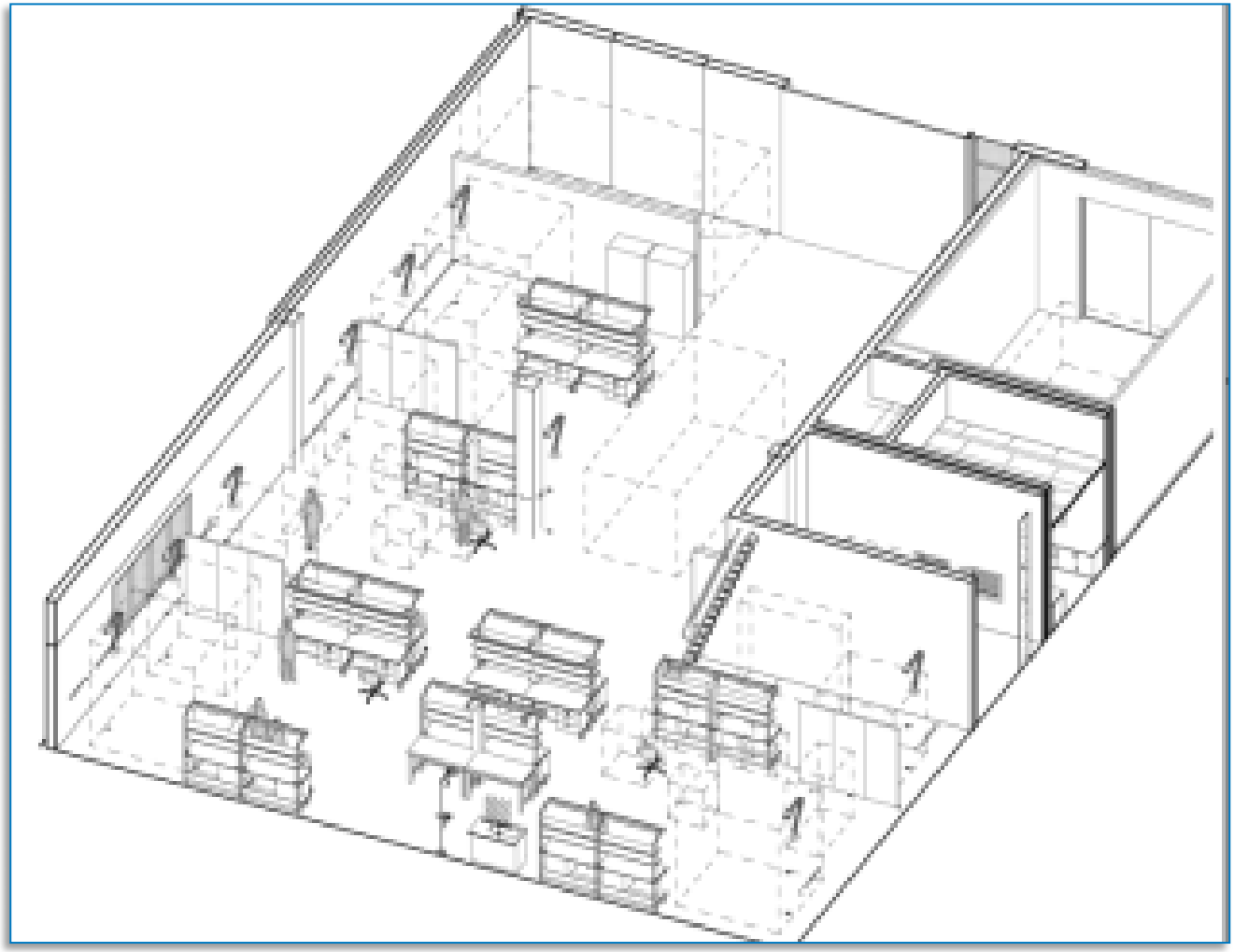
Lab Functions

- Test lab for development and testing of the power electronics components and circuits used in renewable energy integration
- Instrument development area for basic electronics work

Major Laboratory Equipment

- Various mechanical utilities in each test areas such as process cooling water, process heating water, research cooling water (chilled water), dedicated exhaust.
- Various facility power outlets in each test area
- Inverter HIL
- Grid and PV simulators
- AC load banks
- Bidirectional DC supplies
- ELGAR Grid Simulator
- Electronic Load banks.
- Research Chiller
- Research Boiler
- SCADA Data Collection and Control System

ESIF – Energy Storage Lab



ESIF – Energy Storage Lab

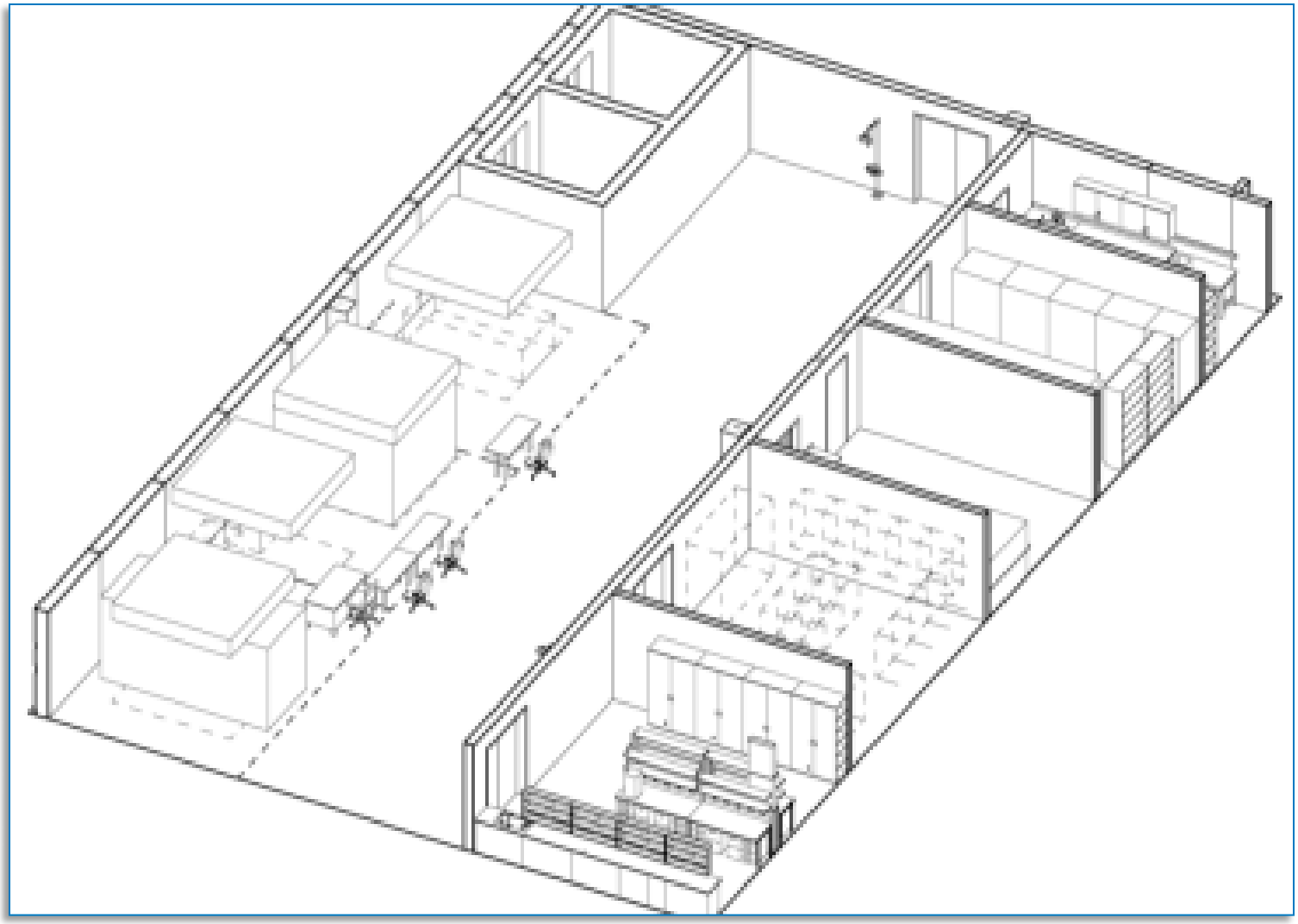
Lab Function

- Resources and systems for testing energy storage component and system performance when integrated with renewable energy electrical systems. Includes batteries, ultra-capacitors, flywheels, compressed air, etc.

Major Laboratory Equipment

- DC Power Testing Station 250 kW, up to 900 Vdc
- Environmental chamber large enough to drive vehicles into
- Electrical research bus connections
- PV simulator and PV power supply
- Process liquids and gases (natural gas, biodiesel, cooling water, heating water, compressed air)
- Advanced data acquisition and monitoring equipment
- Typical Microgrid system components
- Grid simulator
- AC load banks
- Bidirectional DC supplies
- Research Chiller
- Research Boiler
- SCADA Data Collection and Control System

ESIF – Energy Systems Integration Lab



ESIF – Energy Systems Integration Lab

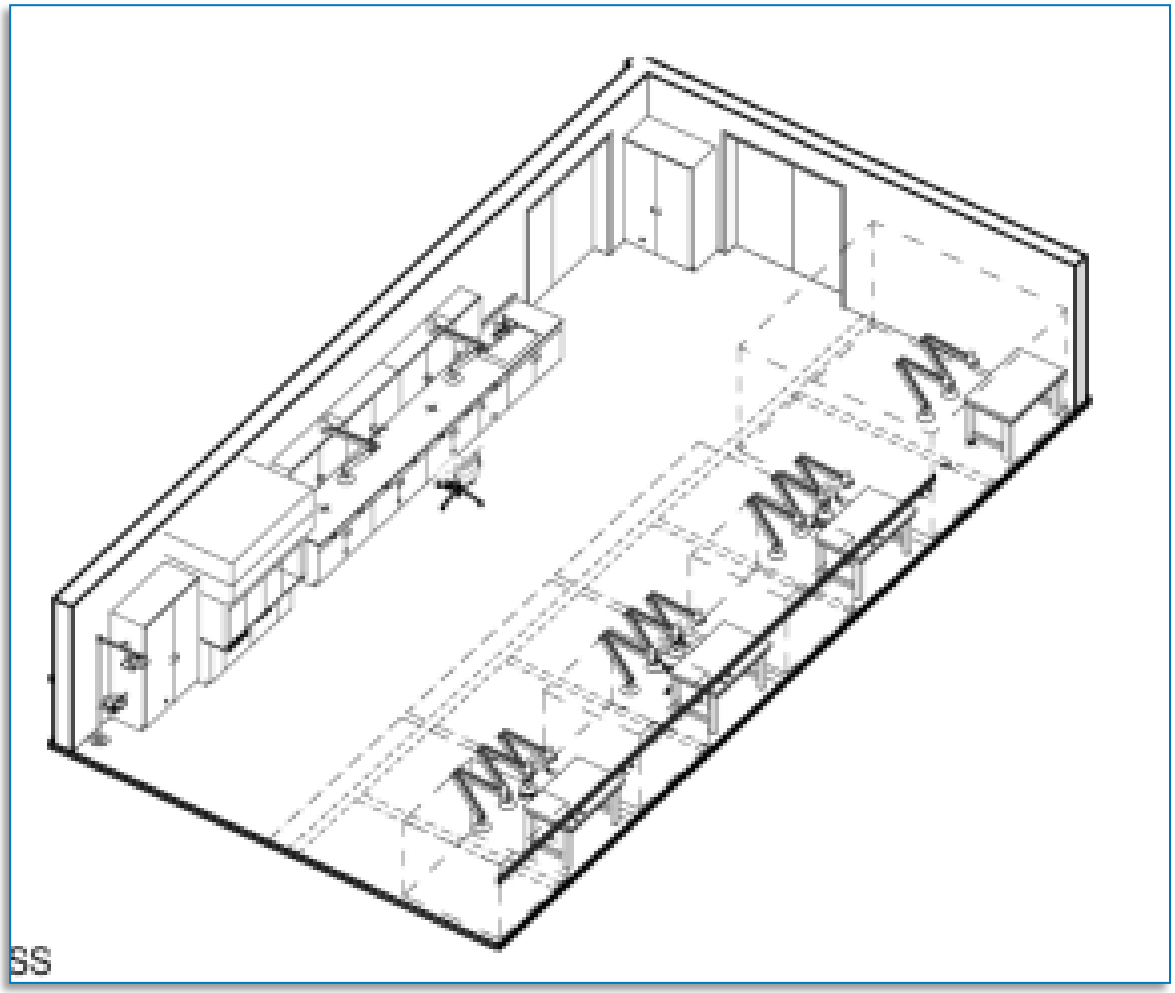
Lab functions

- Laboratory for testing equipment that produces and uses fule systems including hydrogen.
- Testing of electrolyzers, fuel cells, compression equipment, delivery systems.
- Comprised of indoor labs and outdoor test area

Major Laboratory Equipment

- High accuracy hydrogen mass flow systems for improved efficiency monitoring
- PEM electrolyzer
- Alkaline electrolyzer
- Fuel cell
- H2 high pressure compressor
- AC and DC electrical research buss connections
- Advanced data acquisition and monitoring equipment
- Gas Chromatograph
- Ion Chromatograph

ESIF – Thermal Storage Materials Lab



ESIF – Thermal Storage Process Lab

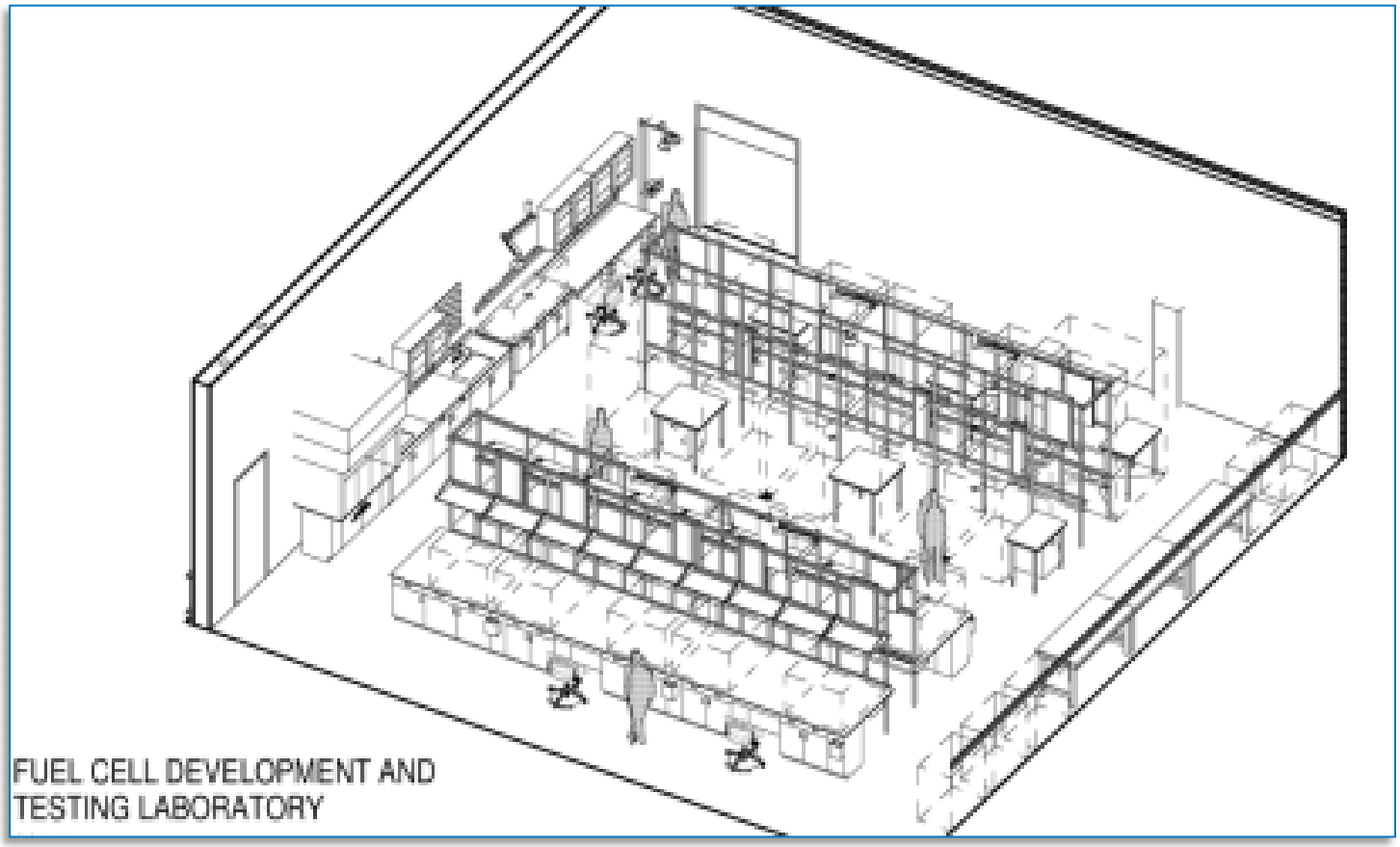
Lab Function

The Thermal Storage Process & Components Lab is utilized to test the performance, compatibility, and cycle life of heat transfer fluids, thermal energy storage processes used for thermal energy storage (TES) systems.

Major Laboratory Equipment

- Differential scanning calorimeter (to 1,200°C)
- Thermal gravimetric analyzer (to 1,100°C)
- High-temperature rheometer (to 1,100°C)
- Densitometer
- Glovebox with HEPA filtration
- Analytical balances and general chemistry supplies
- Controlled atmosphere furnace (to 1,100°C)

ESIF – Fuel Cell Development and Test Lab



ESIF – Fuel Cell Development and Test Lab

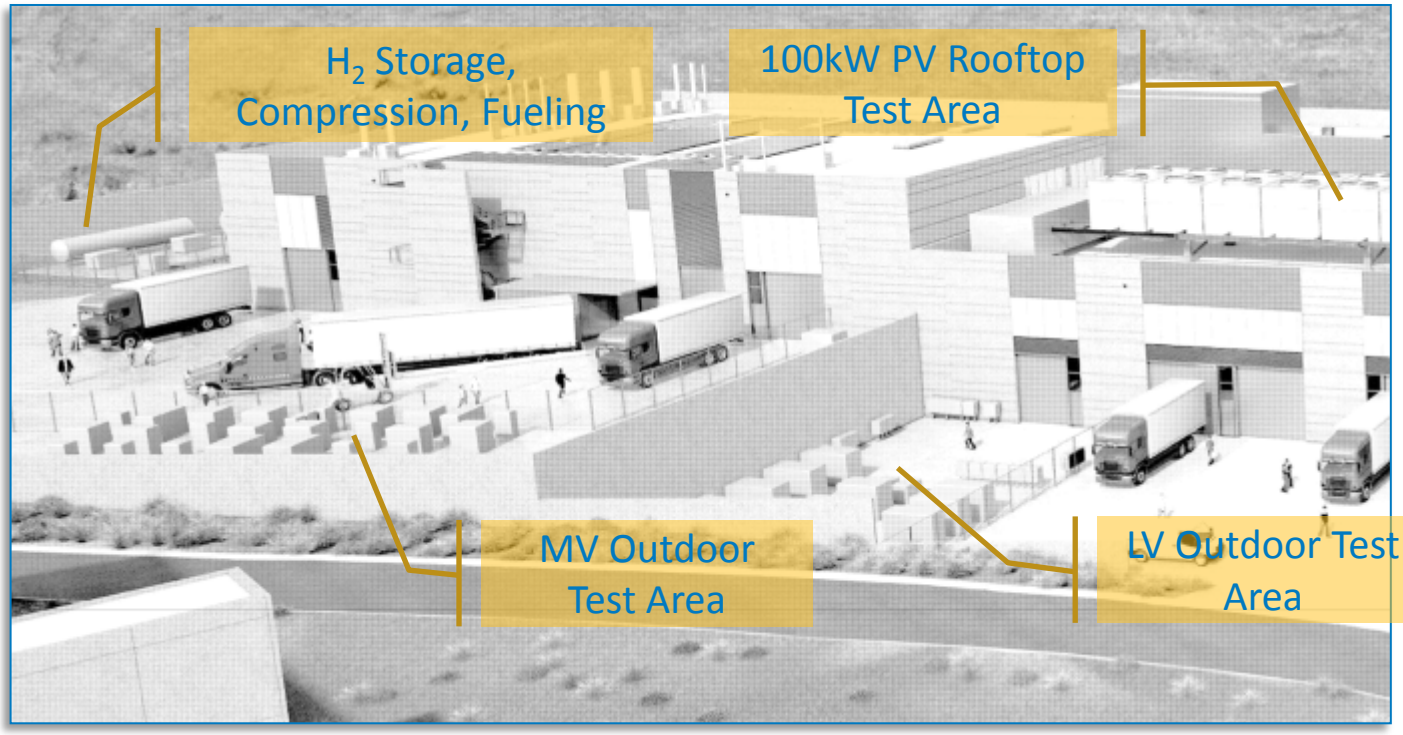
Lab Function

Bench top testing of Fuel Cells and Fuel Cell Stacks. Thermochemical, electrochemical, and thermomechanical analysis of fuel cell MEA materials.

Major Laboratory Equipment

- Single cell fuel cell test stations
  - For PEMFCs sized 5 – 100 cm2
  - Automated backpressure control
  - Various flow configurations
  - Fully calibrated
  - Remote access
- Segmented cell fuel cell test station
  - 50cm2
  - 121 segments, 0.41 cm2 each
  - 121-channel load unit
  - Script execution
- Autolab potentiostat/ galvanostat
- Solartron multi-channel potentiostat/galvanostat
- Calibration Equipment
  - Bios Met Lab ML-800 Flowmeter
  - Vaisala & Viaspace Humidity Sensors
  - Temperature Sensors & Pressure Gauges

ESIF –Outdoor Test Areas



ESIL Major Lab Equipment

- H_2 storage vessels
- H_2 IC engine testing
- H_2 Vehicle fueling station

MV Major Lab Equipment

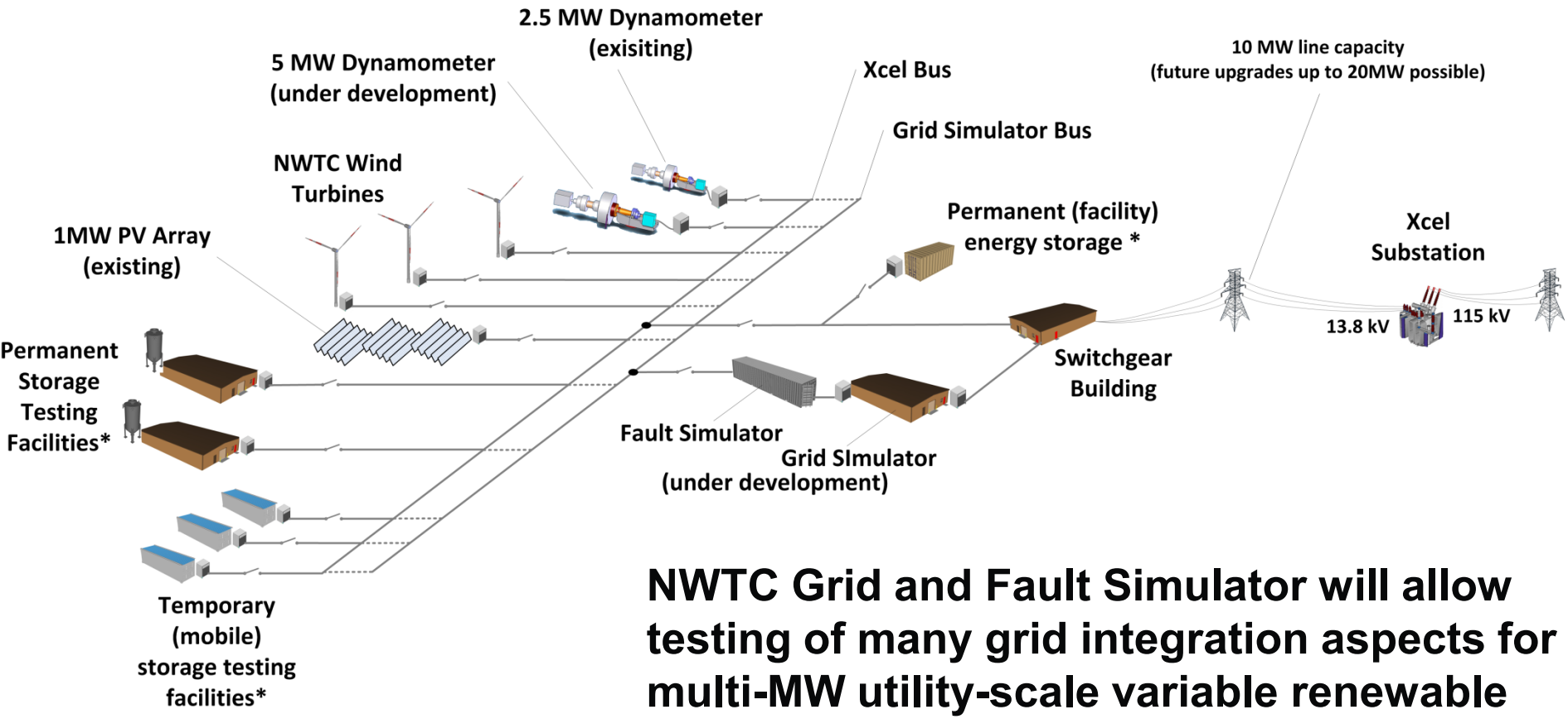
- 1MVA 13.2kV to 480 Y-Y transformers
- Connections to REDB, Utility

LV Major Lab Equipment

- 80kW and 125kW Gensets
- 100kW, 250kW load banks
- Capstone Microturbine
- Connections to REDB

NWTC Grid and Fault Simulator

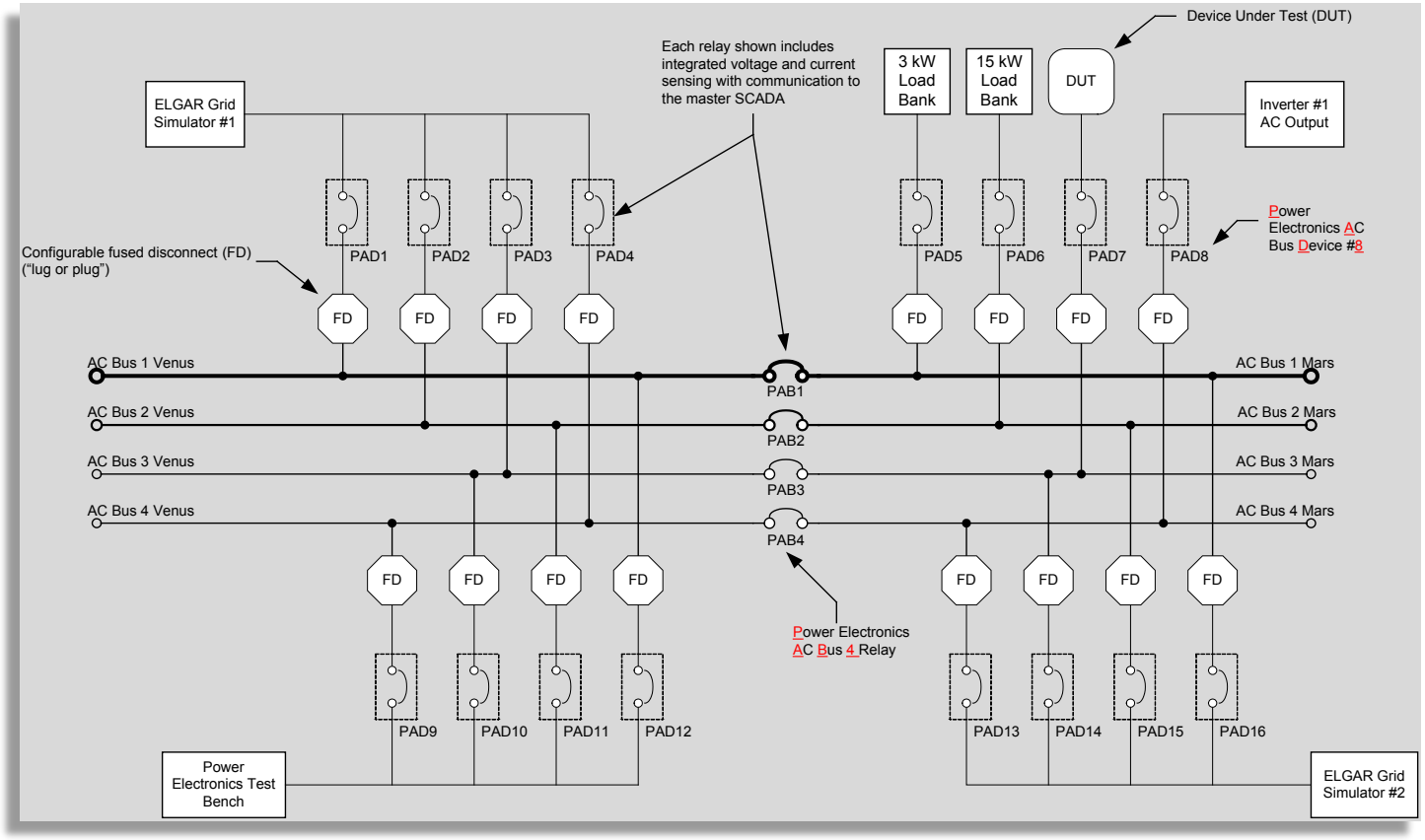
A New Unique Testing Capability



*Storage testing concept is being evaluated

NWTC Grid and Fault Simulator will allow testing of many grid integration aspects for multi-MW utility-scale variable renewable generation and storage technologies.

ESIF's Unique Capabilities



ESIF's Unique Capabilities

- Multiple parallel AC and DC experimental busses with grid simulation
- Flexible interconnection for electricity, thermal and fuels
- Medium voltage microgrid test bed
- Virtual utility operations center and visualization rooms
- Smart grid testing lab for advanced communications and control
- Interconnectivity to external field sites for data feeds and model validation
- Petascale HPC and data mgmt. system
- "Hardware-in-the-loop" simulation capability

Energy Systems Integration Facility (ESIF)

A unique national asset for energy systems integration R&D, testing and analysis